

the same target nucleic acid sequence (regions Y and X in Figure 29), adjacent to and downstream of the first target region (regions X and Z), and the second part of which overlaps into the region defined by the first oligonucleotide (region X depicts the region of overlap). The resulting structure is diagrammed in Figure 29.

5 While not limiting the invention or the instant discussion to any particular mechanism of action, the diagram in Figure 29 represents the effect on the site of cleavage caused by this type of arrangement of a pair of oligonucleotides. The design of such a pair of oligonucleotides is described below in detail. In Figure 29, the 3' ends of the nucleic acids (*i.e.*, the target and the oligonucleotides) are indicated by the use of the arrowheads on the ends of the lines depicting the strands of the nucleic acids (and where space permits, these ends are also labelled "3'"). It is readily appreciated that the two oligonucleotides (the invader and the probe) are arranged in a parallel orientation relative to one another, while the target nucleic acid strand is arranged in an anti-parallel orientation relative to the two oligonucleotides. Further it is clear that the invader oligonucleotide is located upstream of the probe oligonucleotide and that with respect to the target nucleic acid strand, region Z is upstream of region X and region X is upstream of region Y (that is region Y is downstream of region X and region X is downstream of region Z). Regions of complementarity between the opposing strands are indicated by the short vertical lines. While not intended to indicate the precise location of the site(s) of cleavage, the area to which the site of cleavage within the probe oligonucleotide is shifted by the presence of the invader oligonucleotide is indicated by the solid vertical arrowhead. An alternative representation of the target/invader/probe cleavage structure is shown in Figure 32c. Neither diagram (*i.e.*, Fig. 29 or Fig. 32c) is intended to represent the actual mechanism of action or physical arrangement of the cleavage structure and further it is not intended that the method of the present invention be limited to any particular mechanism of action.

It can be considered that the binding of these oligonucleotides divides the target nucleic acid into three distinct regions: one region that has complementarity to only the probe (shown as "Z"); one region that has complementarity only to the invader

(shown as "Y"); and one region that has complementarity to both oligonucleotides (shown as "X").

Design of these oligonucleotides (*i.e.*, the invader and the probe) is accomplished using practices which are standard in the art. For example, sequences that have self complementarity, such that the resulting oligonucleotides would either fold upon themselves, or hybridize to each other at the expense of binding to the target nucleic acid, are generally avoided.

One consideration in choosing a length for these oligonucleotides is the complexity of the sample containing the target nucleic acid. For example, the human genome is approximately  $3 \times 10^9$  basepairs in length. Any 10 nucleotide sequence will appear with a frequency of  $1:4^{10}$ , or 1:1048,576 in a random string of nucleotides, which would be approximately 2,861 times in 3 billion basepairs. Clearly an oligonucleotide of this length would have a poor chance of binding uniquely to a 10 nucleotide region within a target having a sequence the size of the human genome. If the target sequence were within a 3 kb plasmid, however, such an oligonucleotide might have a very reasonable chance of binding uniquely. By this same calculation it can be seen that an oligonucleotide of 16 nucleotides (*i.e.*, a 16-mer) is the minimum length of a sequence which is mathematically likely to appear once in  $3 \times 10^9$  basepairs.

A second consideration in choosing oligonucleotide length is the temperature range in which the oligonucleotides will be expected to function. A 16-mer of average base content (50% G-C basepairs) will have a calculated  $T_m$  (the temperature at which 50% of the sequence is dissociated) of about 41°C, depending on, among other things, the concentration of the oligonucleotide and its target, the salt content of the reaction and the precise order of the nucleotides. As a practical matter, longer oligonucleotides are usually chosen to enhance the specificity of hybridization. Oligonucleotides 20 to 25 nucleotides in length are often used as they are highly likely to be specific if used in reactions conducted at temperatures which are near their  $T_m$ s (within about 5° of the  $T_m$ ). In addition, with calculated  $T_m$ s in the range of 50° to 70°C, such oligonucleotides (*i.e.*, 20 to 25-mers) are appropriately used in reactions catalyzed by

thermostable enzymes, which often display optimal activity near this temperature range.

The maximum length of the oligonucleotide chosen is also based on the desired specificity. One must avoid choosing sequences that are so long that they are either at a high risk of binding stably to partial complements, or that they cannot easily be dislodged when desired (*e.g.*, failure to disassociate from the target once cleavage has occurred).

The first step of design and selection of the oligonucleotides for the invader-directed cleavage is in accordance with these sample general principles. Considered as sequence-specific probes individually, each oligonucleotide may be selected according to the guidelines listed above. That is to say, each oligonucleotide will generally be long enough to be reasonably expected to hybridize only to the intended target sequence within a complex sample, usually in the 20 to 40 nucleotide range. Alternatively, because the invader-directed cleavage assay depends upon the concerted action of these oligonucleotides, the composite length of the 2 oligonucleotides which span/bind to the X, Y, Z regions may be selected to fall within this range, with each of the individual oligonucleotides being in approximately the 13 to 17 nucleotide range. Such a design might be employed if a non-thermostable cleavage means were employed in the reaction, requiring the reactions to be conducted at a lower temperature than that used when thermostable cleavage means are employed. In some instances, it may be desirable to have these oligonucleotides bind multiple times within a target nucleic acid (*e.g.*, which bind to multiple variants or multiple similar sequences within a target). It is not intended that the method of the present invention be limited to any particular size of the probe or invader oligonucleotide.

The second step of designing an oligonucleotide pair for this assay is to choose the degree to which the upstream "invader" oligonucleotide sequence will overlap into the downstream "probe" oligonucleotide sequence, and consequently, the sizes into which the probe will be cleaved. A key feature of this assay is that the probe oligonucleotide can be made to "turn over," that is to say cleaved probe can be made to depart to allow the binding and cleavage of other copies of the probe molecule,